PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : F23R 3/00

A1

(11) International Publication Number: WO 99/06771

(43) International Publication Date: 11 February 1999 (11.02.99)

(21) International Application Number: PCT/US98/16078

(22) International Filing Date: 30 July 1998 (30.07.98)

(30) Priority Data:

60/054,496	31 July 1997 (31.07.97)	US
09/088,762	2 June 1998 (02.06.98)	US

(71) Applicant: ALLIEDSIGNAL INC. [US/US]; 101 Columbia Road, Morristown, NJ 07962-2245 (US).

(72) Inventors: CUNNINGTON, George, R.; 2880 S. Los Altos Place, Chandler, AZ 85248 (US). LENERTZ, James, E.; 8385 E. Peppertree Lane, Scottsdale, AZ 85251 (US).

(74) Agents: BUFF, Ernest, D. et al.; Riker, Danzig, Scherer, Hyland & Perretti LLP, Headquarters Plaza, One Speedwell Avenue, Morristown, NJ 07962-1981 (US).

(81) Designated States: CN, ID, JP, KR, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

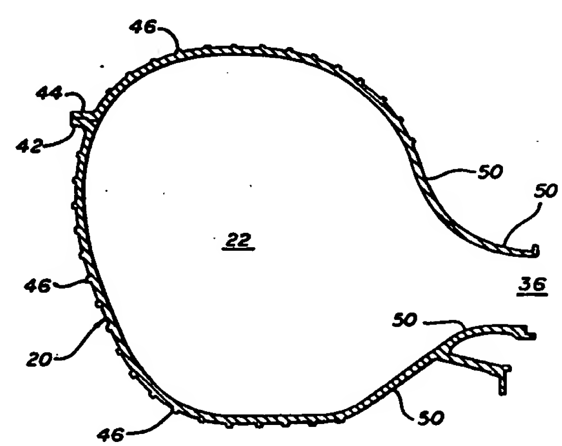
Published

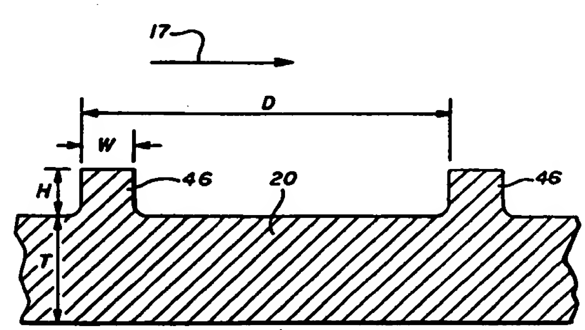
With international search report.

(54) Title: RIB TURBULATORS FOR COMBUSTOR EXTERNAL COOLING

(57) Abstract

A cast combustor liner having integrally cast turbulators on the exterior, cooling surface thereof which increase the cooling air heat transfer coefficient of the combustor liner.





FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

RIB TURBULATORS FOR COMBUSTOR EXTERNAL COOLING

Priority is claimed to provisional application Serial No. 60/054,496, filed July 31, 1997.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention pertains to gas turbine engines and pertains more particularly to a low cost, improved combustor liner and cooling therefor.

2. Description of the Prior Art

The combustor of a gas turbine typically includes a combustor liner which encloses the hot combustion zone. Cooling of the combustor liner is critical for engine operation. The combustor liner is typically cooled either by film cooling or effusion cooling. Such cooling techniques are inherently based upon penetration of the cooling air through the combustor wall. Certain applications however are not amenable to effusion cooling or film cooling except by construction of an expensive combustor liner.

SUMMARY OF THE INVENTION

It is an important object of the present invention to provide an improved combustor liner which can be inexpensively manufactured. More specifically, it is an object of the present invention to provide a cast combustor liner, and to provide an inexpensive manner of convectively cooling the cast combustor liner.

More particularly, the present invention contemplates a cast combustor liner which has an exterior surface exposed to cooling airflow received from the compressor section of the gas turbine engine for convective cooling of the liner, along with a plurality of turbulators integrally cast upon the liner's exterior surface for increasing the heat transfer coefficient of the combustor liner.

These and other objects and advantages of the present invention are specifically set forth in or will become apparent from the following detailed description of the invention when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

Fig. 1 is a partial elevational cross-sectional view of a portion of a gas turbine engine utilizing the present invention;

Fig. 2 is a perspective of the combustor casing and associated assembly;

Fig. 3 is an enlarged elevational cross-sectional view of the combustor liner;

Fig. 4 is a plan cross-sectional view of a portion of the combustor;

Fig. 5 is an elevation of the exterior surface of the combustor liner; and

Fig. 6 is an enlarged cross-section of the combustor liner showing details of the turbulators.

DETAILED DESCRIPTION OF THE INVENTION

Referring now more particularly to the drawings, a gas turbine engine 10 conventionally includes a combustor section 12 driven by a turbine section 14 through axially extending shaft 16. Highly compressed air 17 is delivered from combustor section 12 to a combustor generally denoted by the numeral 18, and hot gases exit the compressor 18 to drive the turbine section 14.

The particular combustor 18 illustrated is of a type wherein airflow to the combustor zone of the combustor is modulated or adjusted for pollution control purposes. This type of arrangement is illustrated and described in detail in U.S. Patents 5,477,671 and 5, 481,866 of R. J. Mowill, as well as copending U.S. Patent Application Serial No. 08/66,393 filed November 7, 1997 entitled " Combustion Dilution Bypass System" of James Lenertz, et al, and commonly assigned herewith. To the extent necessary for a complete understanding of the present invention, these patents and application are incorporated herein by reference.

Briefly, this type of combustor 18 includes a combustor liner 20, described in greater detail below, of annular configuration having toroidal cross-section. Combustor liner 20 encloses the internal combustor zone 22 of the combustor. A fuel/air mixture is admitted into the combustor zone 22 through a pair of venturi's 24, one of which is shown in Figs. 2 and 4. Compressed air 17 from the compressor section 12 is routed inside combustor casing 19 and about the exterior of combustor liner 20, then through a duct 26 to be controlled by a three-way valve 28. A portion of the air is bypassed through a combustor bypass 30, while the remaining compressed air flow is directed through duct 32 into the venturi 24. Fuel is admitted through fuel nozzle 34, and intimate mixing thereof occurs within the venturi 24 before subsequent

introduction into the combustion zone 22 through opening 25. It will be noted that a three-way valve and associated ducting is included for the other venturi, not shown. Combustion occurs within zone 22 and passes through the combustor exit 36 to be delivered to the power turbine section 14.

The bypass air going through bypass duct 30 is collected in a chamber 38 and then passes through a plurality of bypass tubes 40 for reintroduction into the main combustor gas flow adjacent the exit 36, as described in greater detail below.

The improved combustor liner 20 of the present invention is illustrated in greater detail in Fig. 3, 5 and 6. Importantly, combustor 20 is of low cost construction inasmuch as it is a cast structure. Preferably, it is a multiple part casting. In the embodiment illustrated, liner 20 is a two-part casting which mating part line lips 42, 44. The casting parts are, of course, rigidly and sealingly intersecured to one another. The relatively complex geometry of the annularly shaped, irregularly toroidal cross-section of combustor liner 20 may readily be produced via casting processes.

Integrally cast on the exterior surface of the combustor liner 20 are a plurality of upstanding ribs or turbulators 46. In the arrangement illustrated the turbulators are disposed approximately perpendicular to the central axis 48 of the gas turbine engine such that the airflow from the compressor section 17 crosses the pattern of the turbulators 46. If there is no swirl in the airflow 17 exiting the compressor section, the turbulators will be at about 90 degrees to the airflow direction. Preferably the turbulators are arranged between 45 degrees and 90 degrees to the direction of airflow 17. In the preferred pattern illustrated, each of the turbulators 46 extend in a circle about the exterior surface of toroidally shaped combustor, thus presenting a pattern of

circular ringlets. This pattern is readily amenable to casting processes with simple tooling.

Turbulators 46 are sized and configured to enhance the heat transfer coefficient of combustor liner 20 by periodically tripping or interrupting the boundary layer of the airflow 17 from the compressor section . Adjacent turbulators are spaced from one another a sufficient distance to permit reattachment and regrowth of the boundary layer before encountering the next turbulator 46. This periodic reattachment and regrowth of the boundary liner results in a periodic cooling air heat transfer coefficient increase. The net effect is that the average heat transfer coefficient is increased on the exterior surface of combustor liner 20.

The turbulators 46 are of quite small height, however, just enough to cause tripping of the boundary layer but without introducing any significant pressure drop to the compressed airflow 17 flowing there across. That is, the turbulators 46 are not included for the purpose of increasing the cooling surface area of the exterior of liner 20, as such would introduce a pressure drop thereacross. Rather, instead of increasing the cooling surface area, the turbulators increase the cooling heat transfer coefficient through the periodic tripping, reattachment and regrowth of the boundary layer.

In a preferred arrangement the ratio of the width, W, of the turbulators 46 to their height, H, is between about approximately 1 to 2. While the cast combustor liner 20 is of a very thin wall construction with a thickness, T, the height, H, of the turbulators is significantly smaller than this thickness, T. The distance, D, between adjacent turbulators is also carefully controlled to permit the reattachment and regrowth of the tripped boundary layer in the space between adjacent turbulators 46. Preferably, the distance, D, is between about 5 and 20 times the width, W. An

example of a size for the turbulators which has been found to be highly useful in increasing the heat transfer coefficient is a turbulator where W equals about 0.07 inches, H equals about 0.07 inches, and D equals about 0.7 inches. Preferably, the outer corners of the turbulators are relatively sharp. For casting cost reduction purposes, the outer corners can be slightly without impairing the effectiveness of operation of the turbulators.

Adjacent the combustor exit 36, the combustor liner 20 includes a plurality of dilution orifices 50 drilled therethrough. The bypass airflow from bypass tubes 40 passes through the dilution orifices 50 for reintroduction into the gas flow proceeding to the turbine section of the engine. The dilution orifices 50 serve to provide effusion cooling for the combustor liner 20 in the narrow-necked exit area 36.

It will be apparent that various other patterns for the ribbed turbulators may be utilized effectively. For example, the turbulators may be arranged in a spiral like pattern across the toroidally shaped exterior surface, swirling around the liner exterior in a screw thread fashion. Further, in certain instances the ribs may be intermittent in length rather than continuous.

Various modifications and alterations to the foregoing detailed description of the preferred arrangement of the invention will be apparent to those skilled in the art. Accordingly, the foregoing should be considered as exemplary and not as limiting to the scope and spirit of the invention as set forth in the appended claims.

Having described the invention with sufficient clarity that those skilled in the art may make and use it, what is claimed is:

CLAIMS

1. A gas turbine engine comprising:

a compressor section;

a turbine section;

a combustor section receiving compressed airflow from the compressor section and delivering heated, motive gas flow to said turbine section;

a cast combustor liner in the combustor section having an exterior surface exposed to the airflow from the compressor section for convective cooling of the liner; and

a plurality of turbulators integrally cast on said exterior surface for increasing the heat transfer coefficient thereof.

2. A gas turbine engine as set forth in Claim 1, wherein said turbulators are sized with a height sufficient to trip the boundary layer of said airflow without causing significant pressure drop in said airflow.

3. A gas turbine engine as set forth in Claim 2, wherein the ratio of the width to the height of the turbulators is between about 1 and 2.

4. A gas turbine engine as set forth in Claim 3, wherein said turbulators are spaced apart in the direction of said airflow a sufficient distance to permit reattachment and growth of said boundary layer before encountering the subsequent turbulator.

5. A gas turbine engine as set forth in Claim 4, wherein said space between adjacent turbulators is between about 5 and 20 times said height of the turbulators.

6. A gas turbine engine as set forth in Claim 5, wherein said turbulators are oriented between approximately 45 degrees and 90 degrees to the direction of said airflow.

7. A gas turbine engine as set forth in Claim 1, wherein said combustor liner is of annular configuration surrounding the central axis of said gas turbine engine.

8. A gas turbine engine as set forth in Claim 7, wherein said turbulators are arranged substantially perpendicular to said central axis.

9. A gas turbine engine as set forth in Claim 8, wherein said cast combustor liner is a multiple part casting.

10 In a gas turbine engine having a compressor section, a combustor section, and a turbine section:

a cast combustor liner enclosing the combustion chamber of the combustor section, said cast liner having an exterior surface exposed to airflow from the compressor section for convective cooling of said cast liner; and

a plurality of cast turbulators integrally cast on said exterior surface of said cast liner for increasing the heat transfer coefficient thereof.

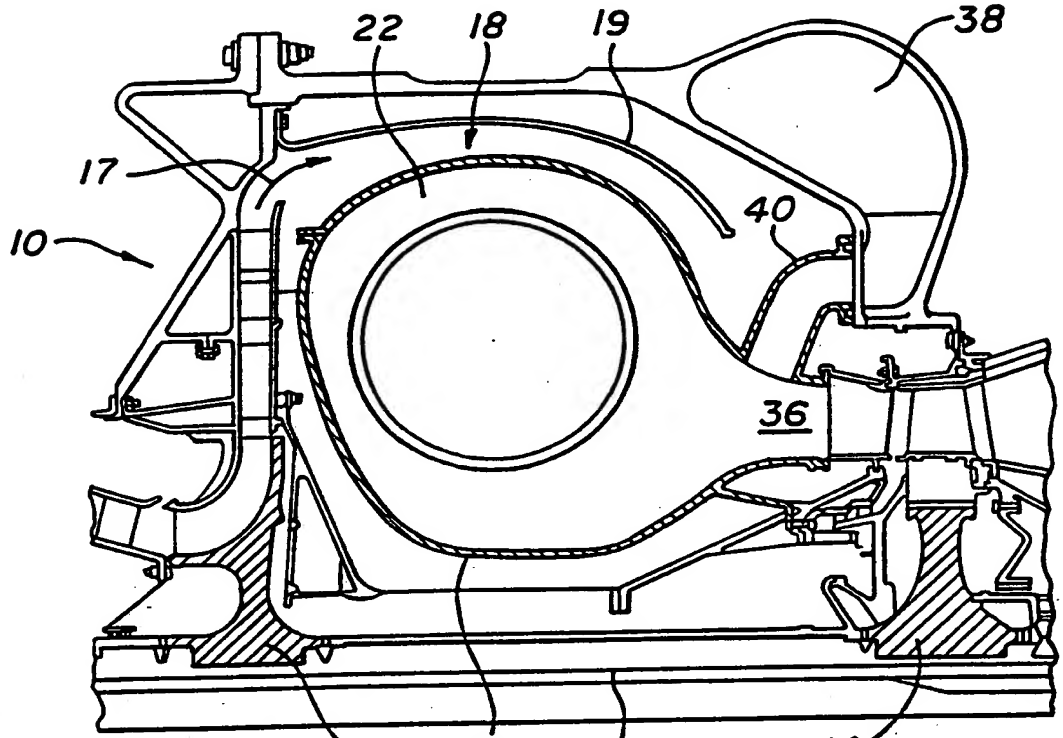
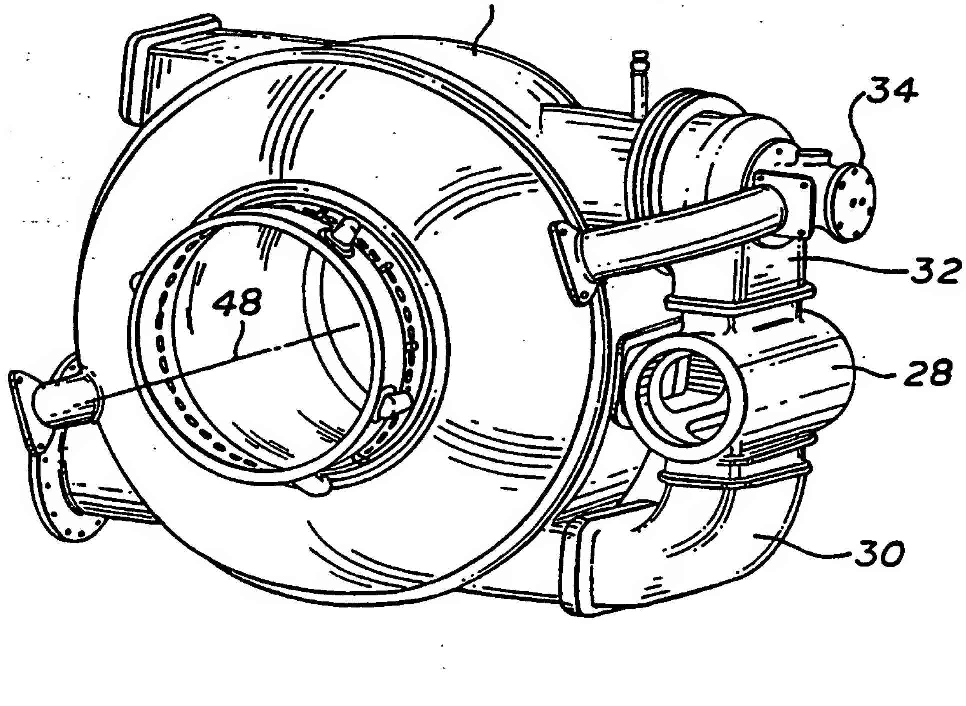


FIG. 1

FIG. 2



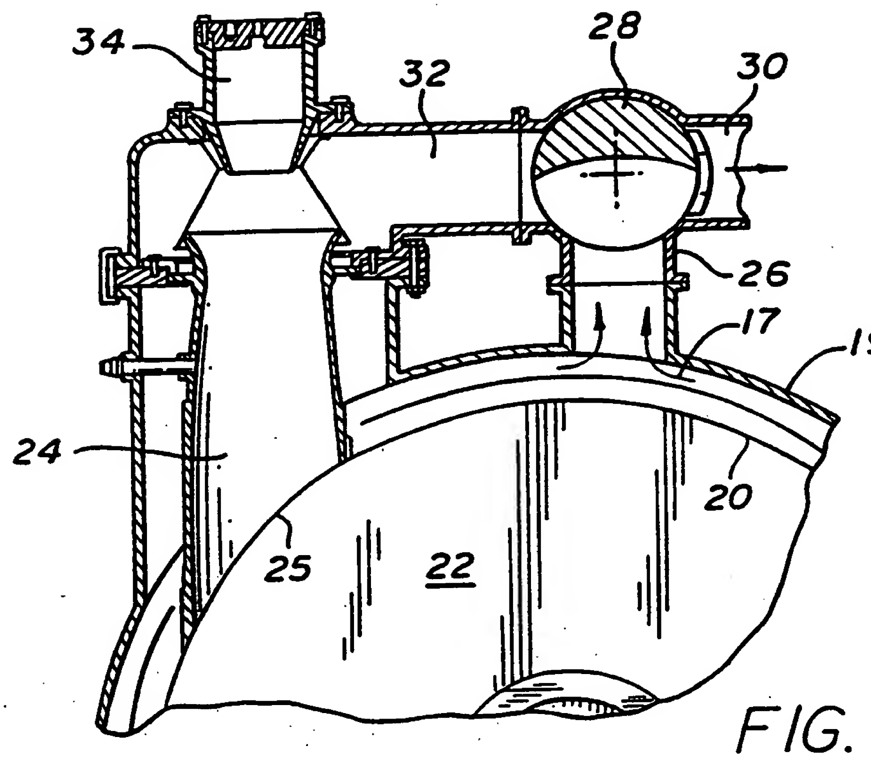


FIG. 4

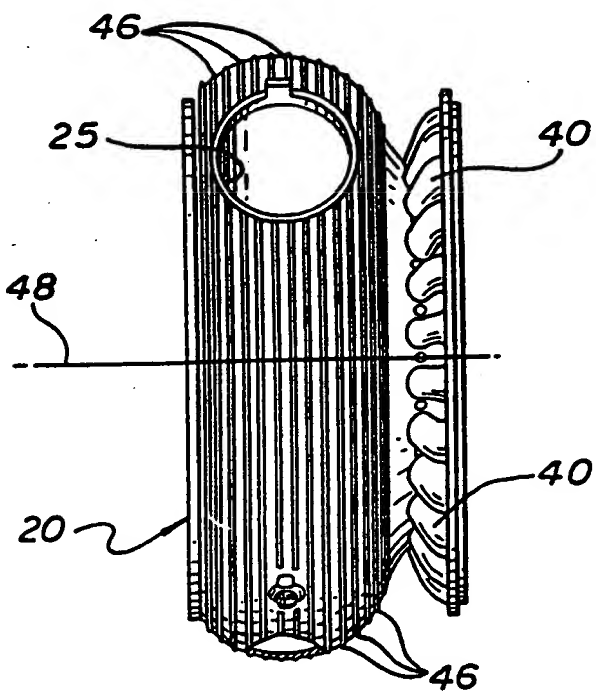


FIG. 5

FIG. 3

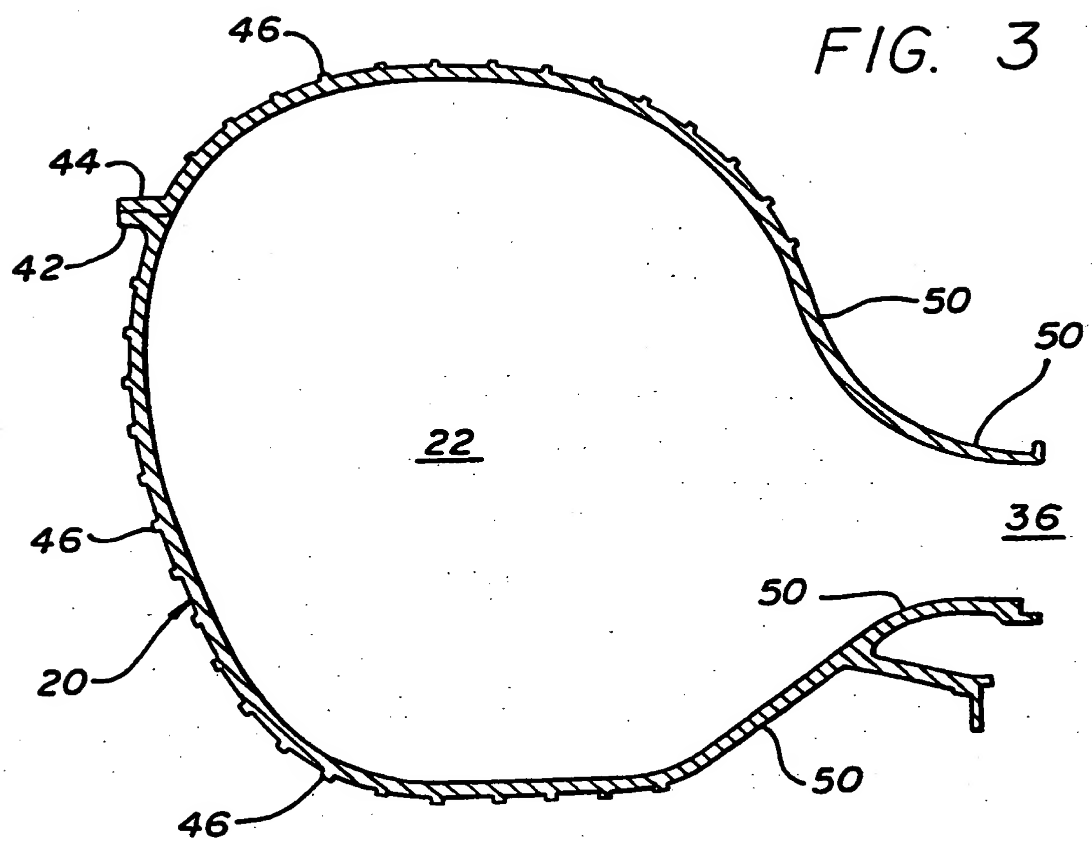
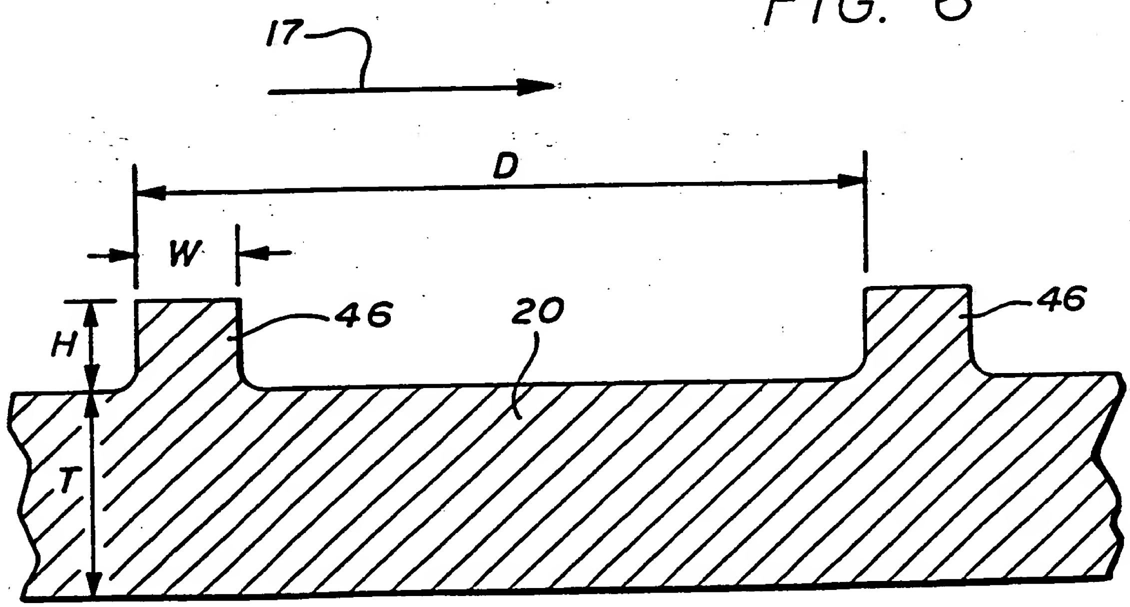


FIG. 6



INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/16078

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F23R3/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 F23R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 024 058 A (SHEKLETON JACK R ET AL) 18 June 1991	1,2,4
Y	see column 6, line 24 - line 48; figure 5	3,5,10
Y	US 5 201 847 A (WHIDDEN GRAYDON L) 13 April 1993 see the whole document	3,5,10
X	US 4 916 905 A (HAVERCROFT PETER ET AL) 17 April 1990 see column 2, line 26 - line 34; figure 2	1,2,10
A	GB 636 811 A (LUCAS LTD.) 10 May 1950 see the whole document	1,10
A	GB 624 285 A (WESTINGHOUSE ELECTRIC INTERNATIONAL COMPANY) 1 June 1949 see the whole document	1,10

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 October 1998	05/11/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Argentini, A

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 98/16078

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5024058 A	18-06-1991	NONE	
US 5201847 A	13-04-1993	CA 2083437 A	22-05-1993
		DE 4238659 A	27-05-1993
		IT 1256169 B	29-11-1995
		JP 2505693 B	12-06-1996
		JP 5214958 A	24-08-1993
US 4916905 A	17-04-1990	GB 2219653 A	13-12-1989
		DE 3842470 A	29-06-1989
		FR 2624954 A	23-06-1989
		JP 1244120 A	28-09-1989
GB 636811 A		NONE	
GB 624285 A		NONE	

Form PCT/ISA/210 (patent family annex) (July 1992)